

PSYCHOLOGY 305

COGNITIVE PROCESSES

Topics for Week 4: Hemispheric specialization

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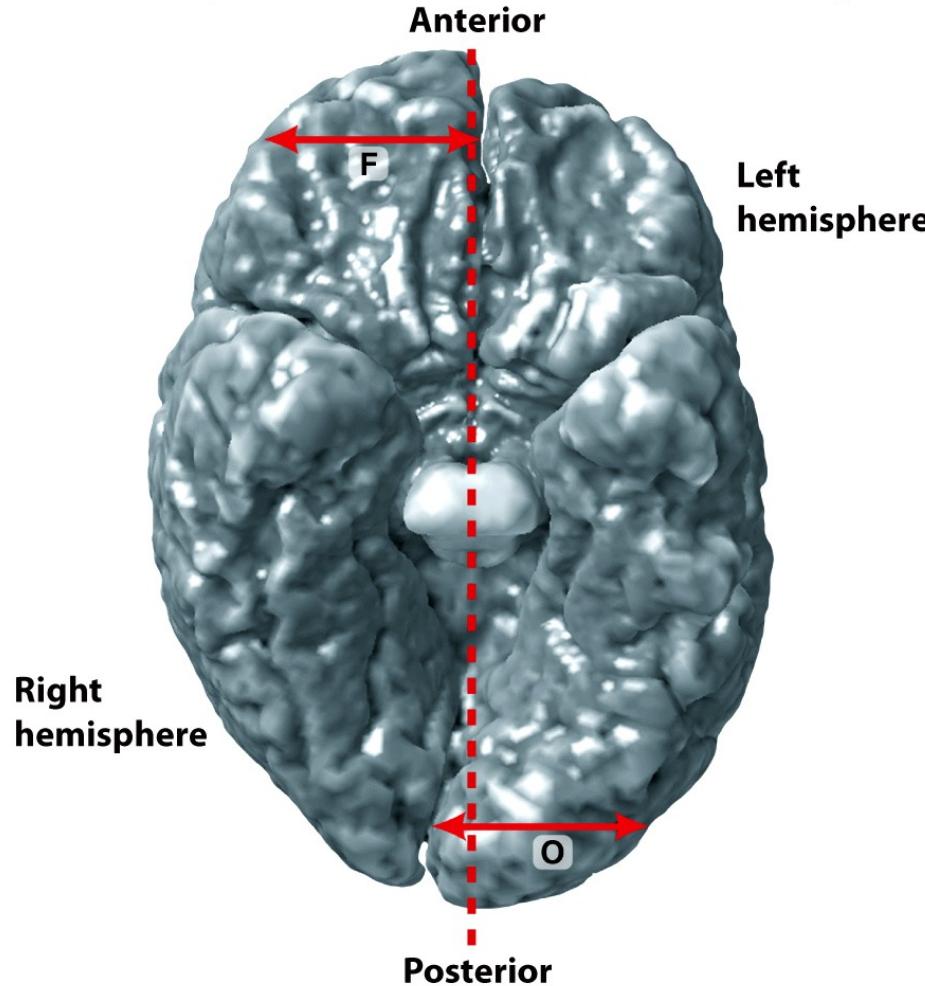
1. Quiz
2. Corpus callosum
3. Split-brain studies
4. Functional asymmetry in ventral pathway
5. Functional asymmetry in dorsal pathway

QUIZ

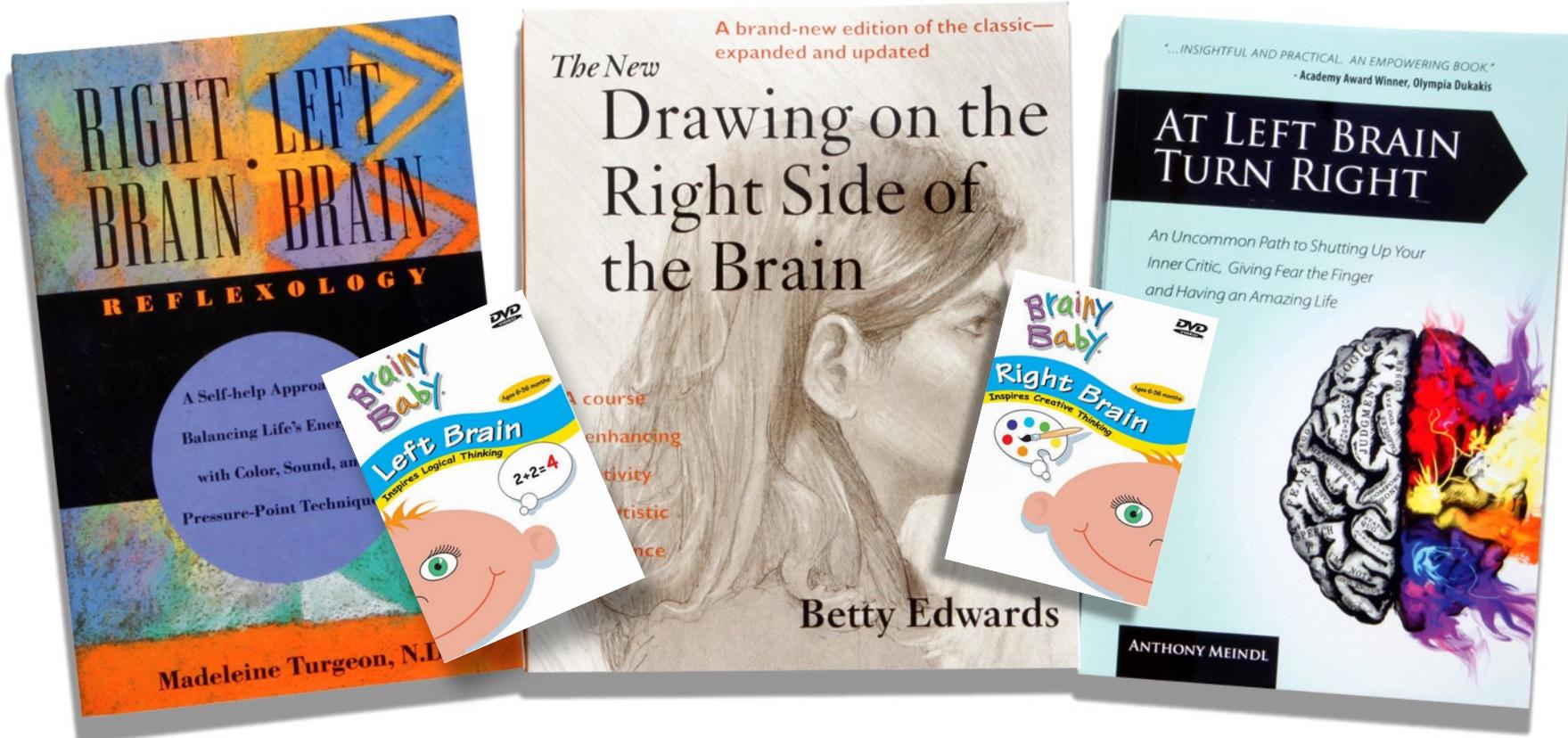
What are the differences between the left and right hemispheres?

Not Completely Symmetrical

Anatomical asymmetries between the two cerebral hemispheres



Folk psychology: left brain is analytic and the right brain is creative.

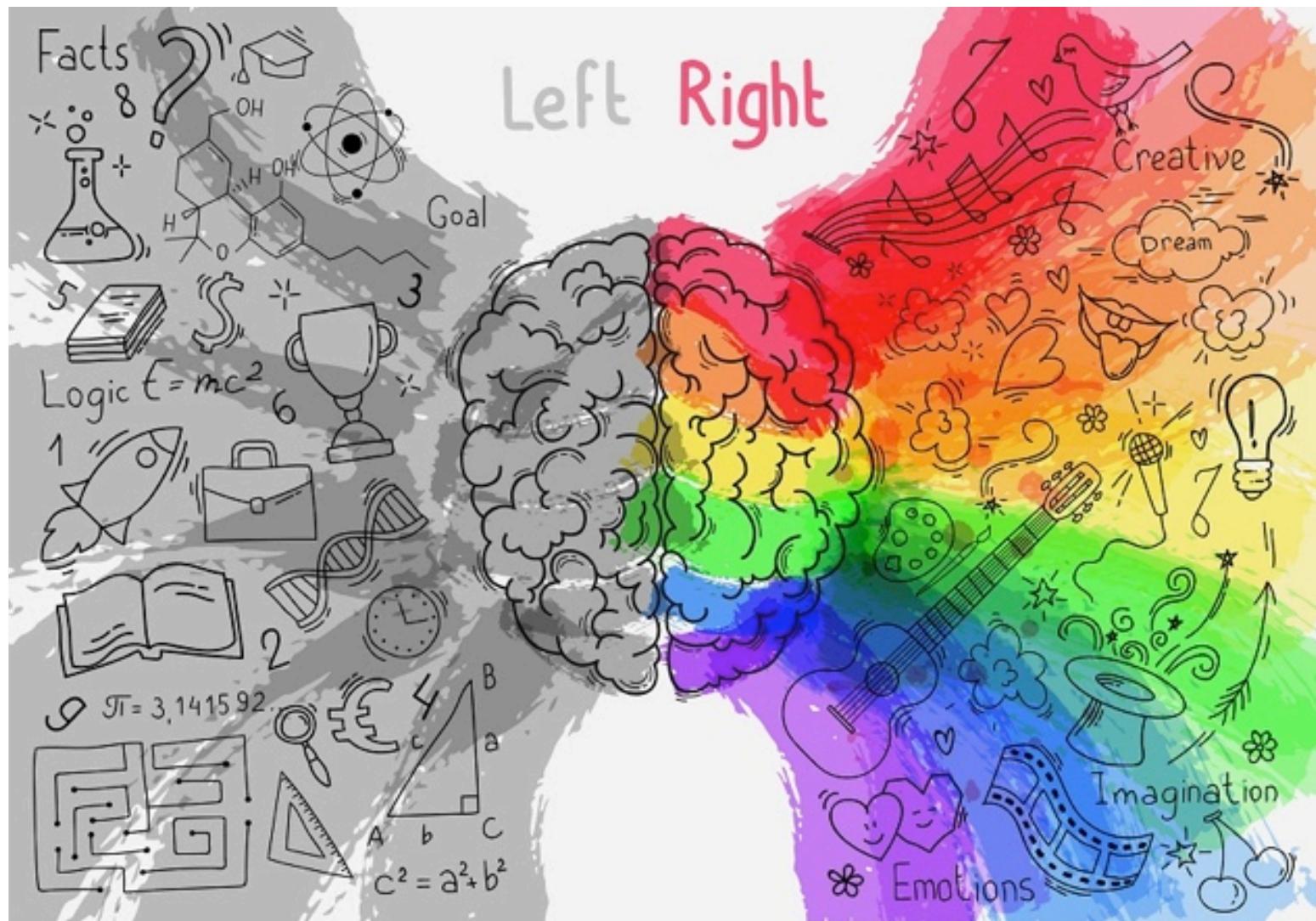


Are you a Left-brainer or Right-brainer?



- Fold your arms in front of the chest
 - a left-brainer: right arm above your left arm,
 - a right-brainer: left arm above your right arm,

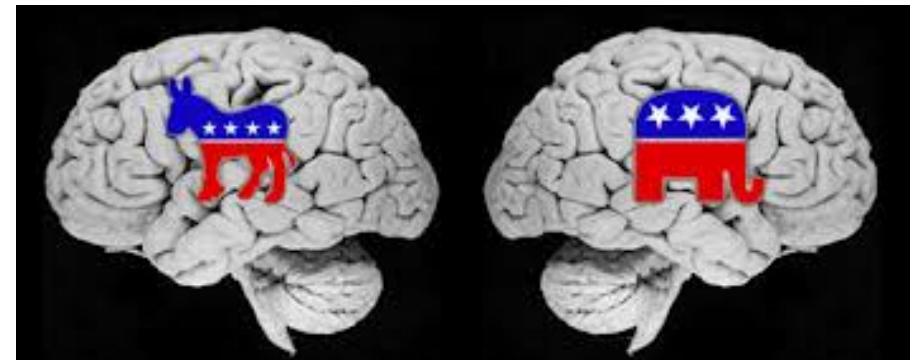
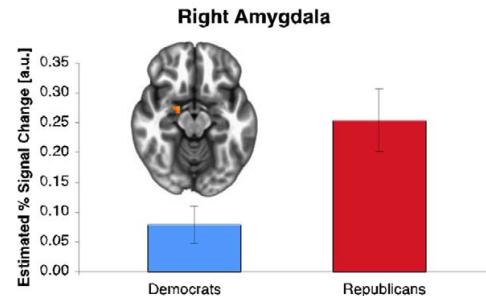
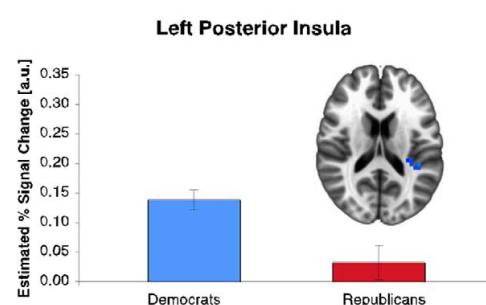
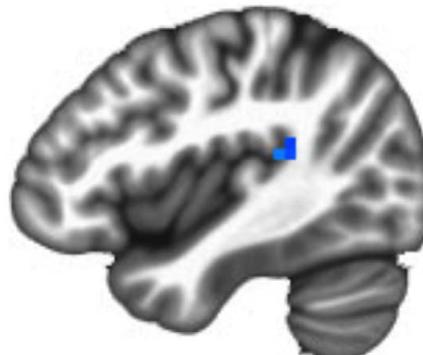
Brain hemisphere differences



Political Brain

Schreiber et al. (2013)

- Democrats: activity in the left posterior insula
- Republicans: increased activities in the right amygdala
- Can predict one's political affiliation with 82.9% of success rate!
- Neuromarketing & politics
- E.g., Republican candidates appearing on the left side in campaign video



Hemispheric Asymmetries: True or False?

- How much can we trust these?
- Need to understand the hemispheric asymmetries and their cognitive effects

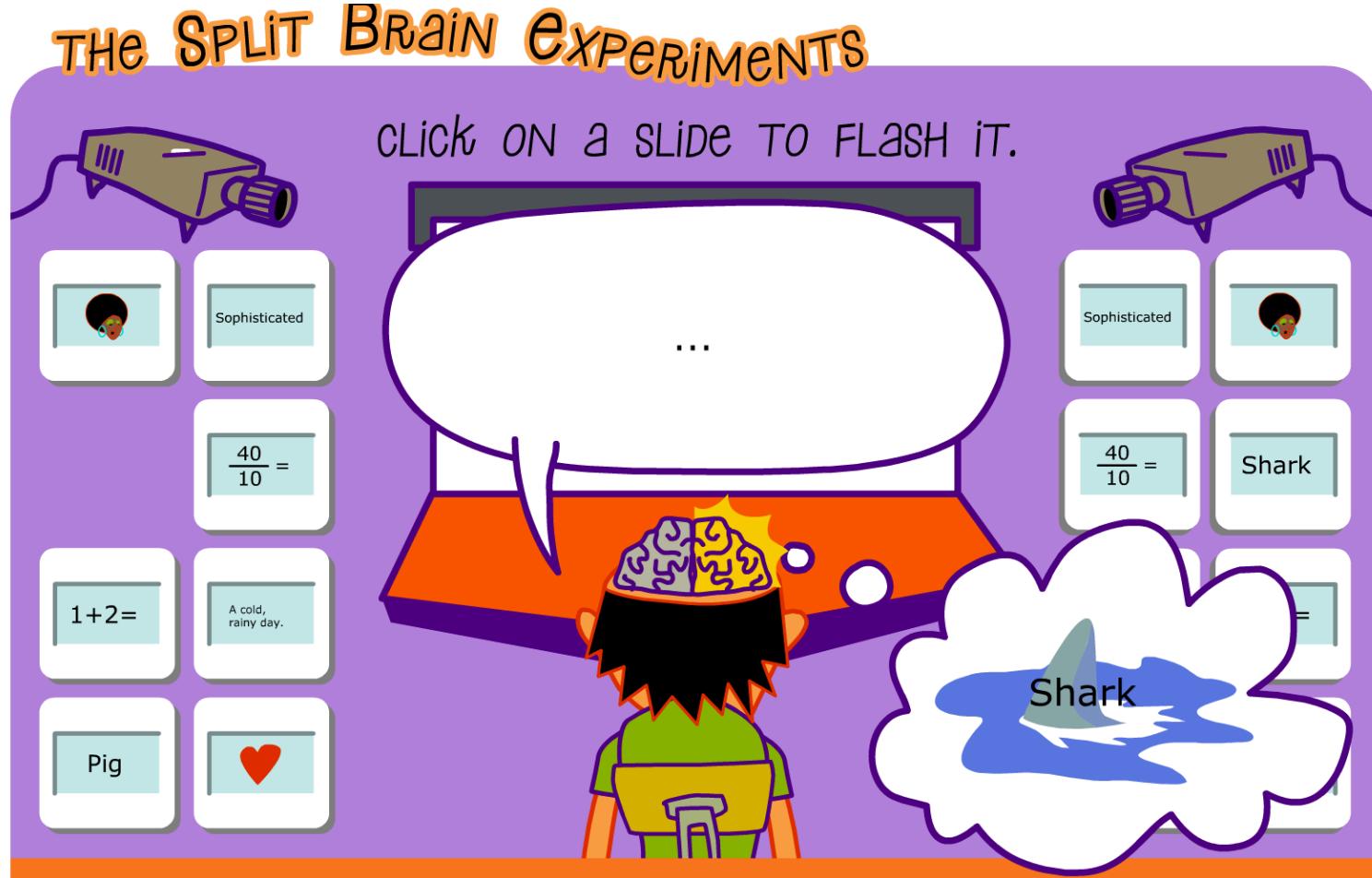
A Little History...

- Scientific research on split-brain patients with the corpus callosum disconnected to treat epileptics
 - Sperry, Roger W. (1961). “Cerebral Organization and Behavior: The Split Brain Behaves in Many Respects Like Two Separate Brains, Providing New Research Possibilities.” *Science* 133 (1961): 1749–57.
 - The Nobel Prize in Physiology or Medicine 1981 awarded to Roger W. Sperry (half), David H. Hubel & Torsten N. Wiesel (the other half)
 - Nobel lecture: Some Effects of Disconnecting the Cerebral Hemispheres, presented by Professor David Ottoson on behalf of Dr. Sperry
 - <http://www.nobelprize.org/mediaplayer/index.php?id=1606>
- Then reached the mainstream press in a big way
 - Pines, Maya. “We Are Left-Brained or Right-Brained; Two Astonishingly Different Persons Inhabit Our Heads.” *New York Times Magazine*, September 9, 1973

Nobel lecture
Some Effects of Disconnecting the Cerebral Hemispheres



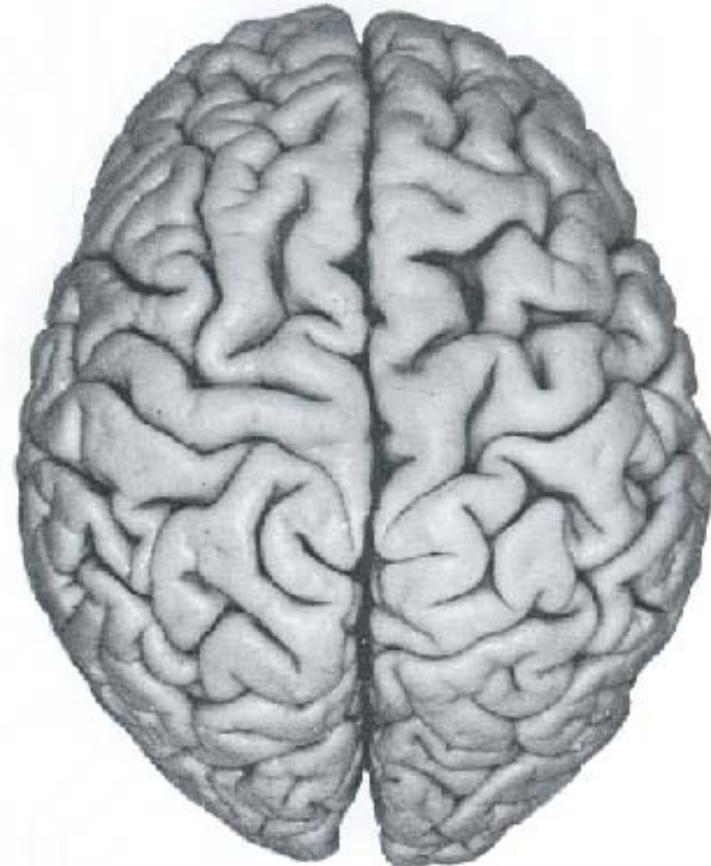
the Split Brain Experiments



"The Split Brain Experiments". Nobelprize.org. Nobel Media AB 2013. Web. 27 Jan 2014. <<http://www.nobelprize.org/educational/medicine/split-brain/index.html>>

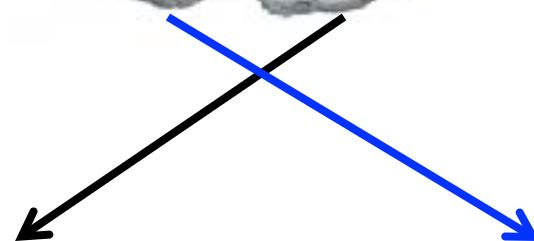
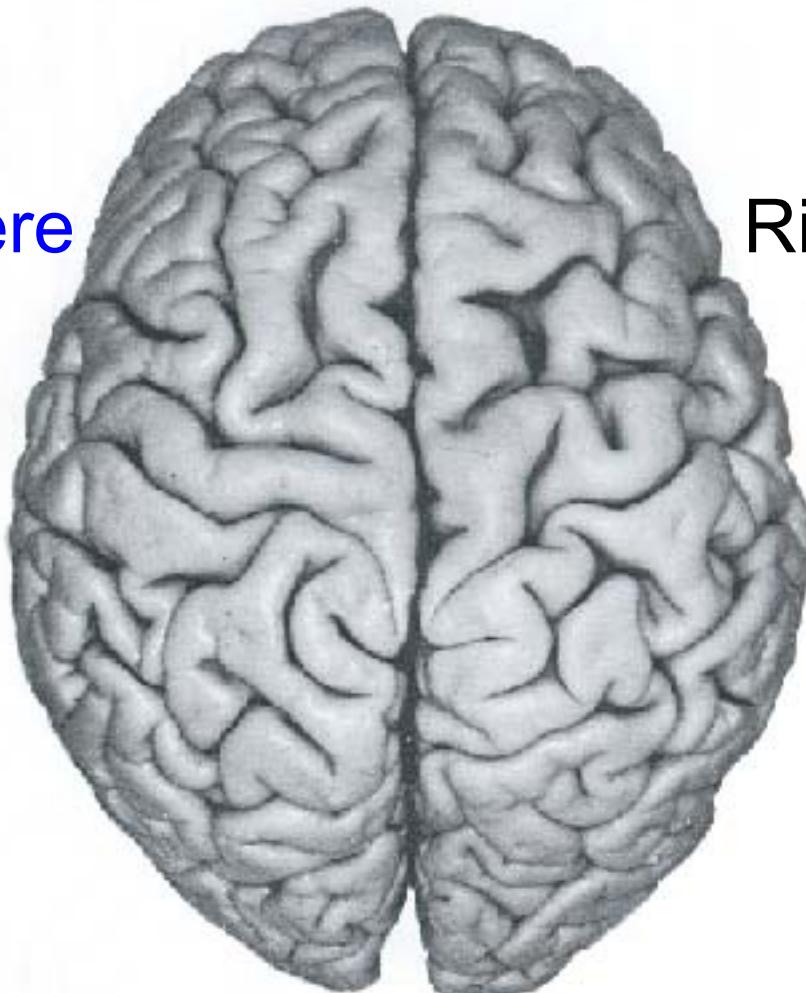
Experimental design: hemispheres

- How do you test the difference?



Left Hemisphere

Right Hemisphere

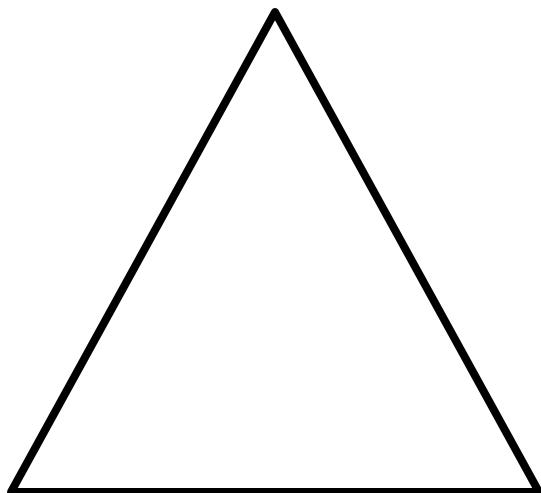


Left hand

Right hand

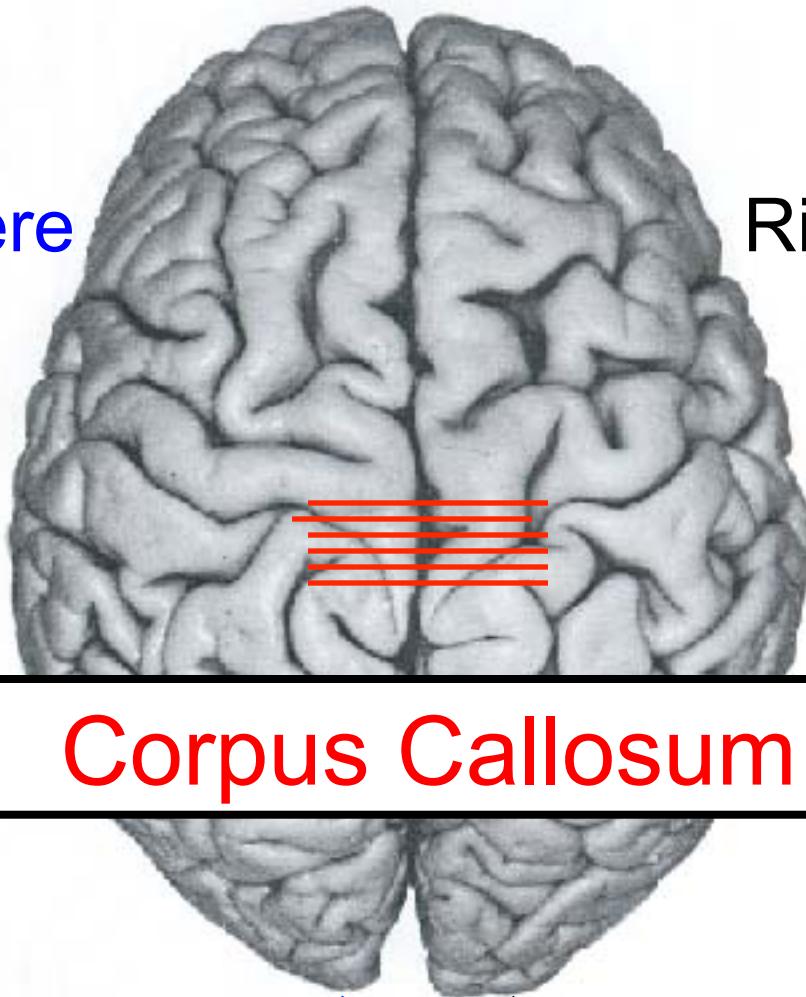
Experimental design: hemispheres

- How do you test the difference?



Left Hemisphere

Right Hemisphere



Corpus Callosum

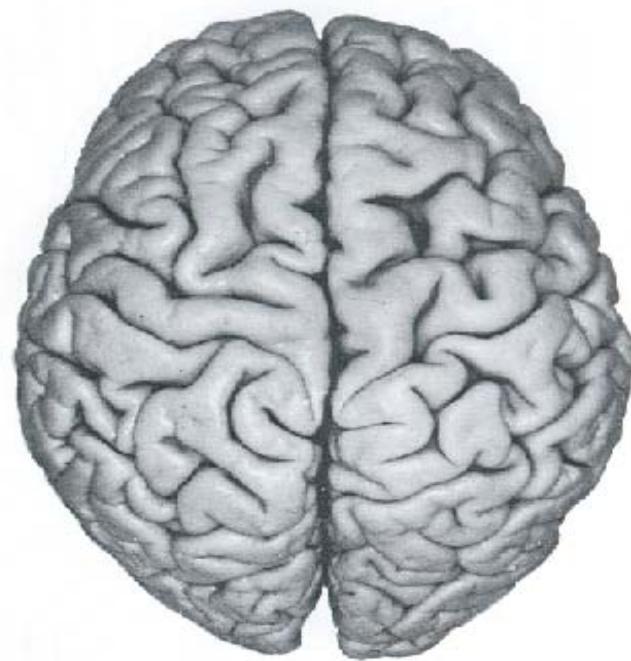
Left hand Right hand

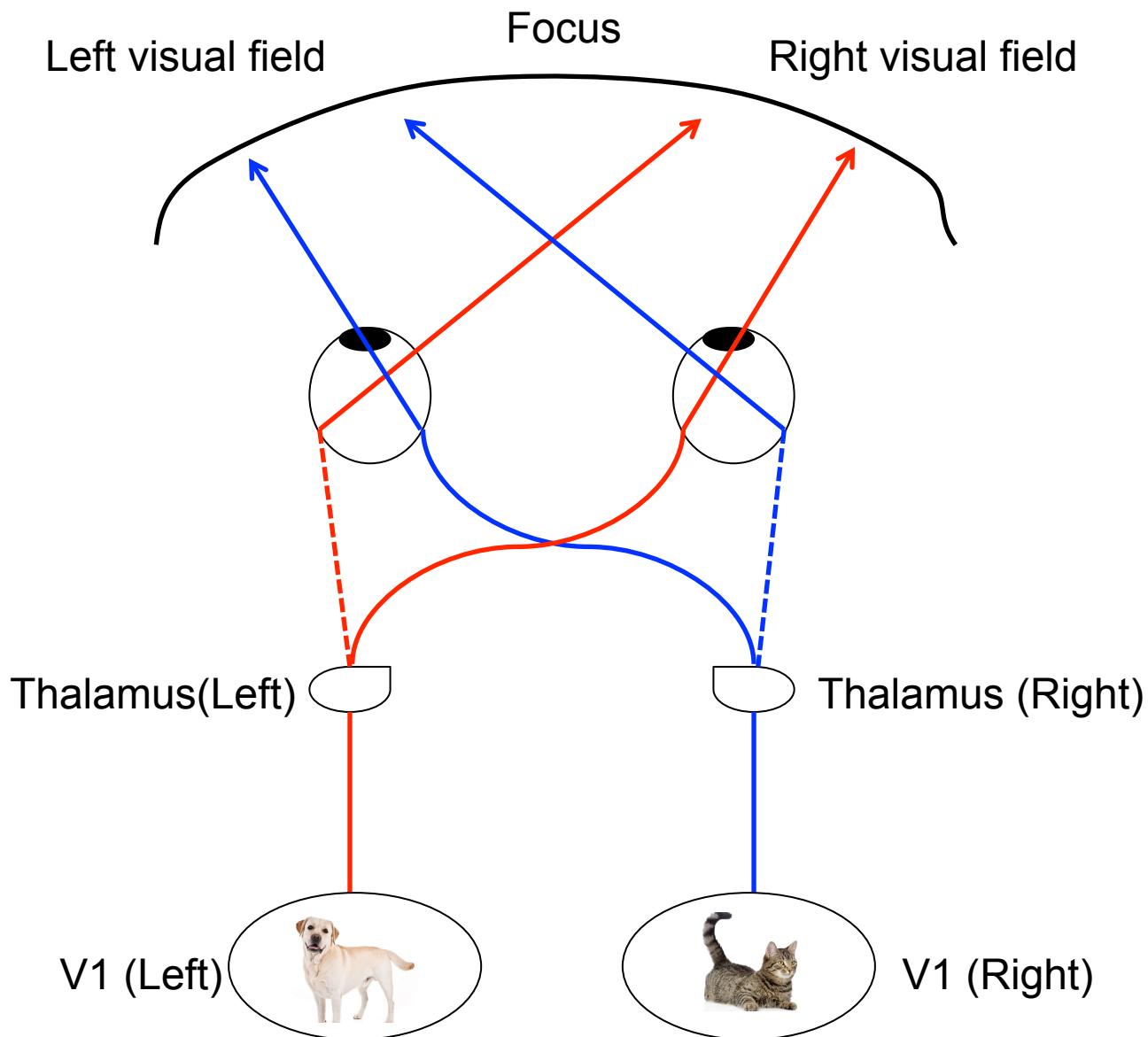


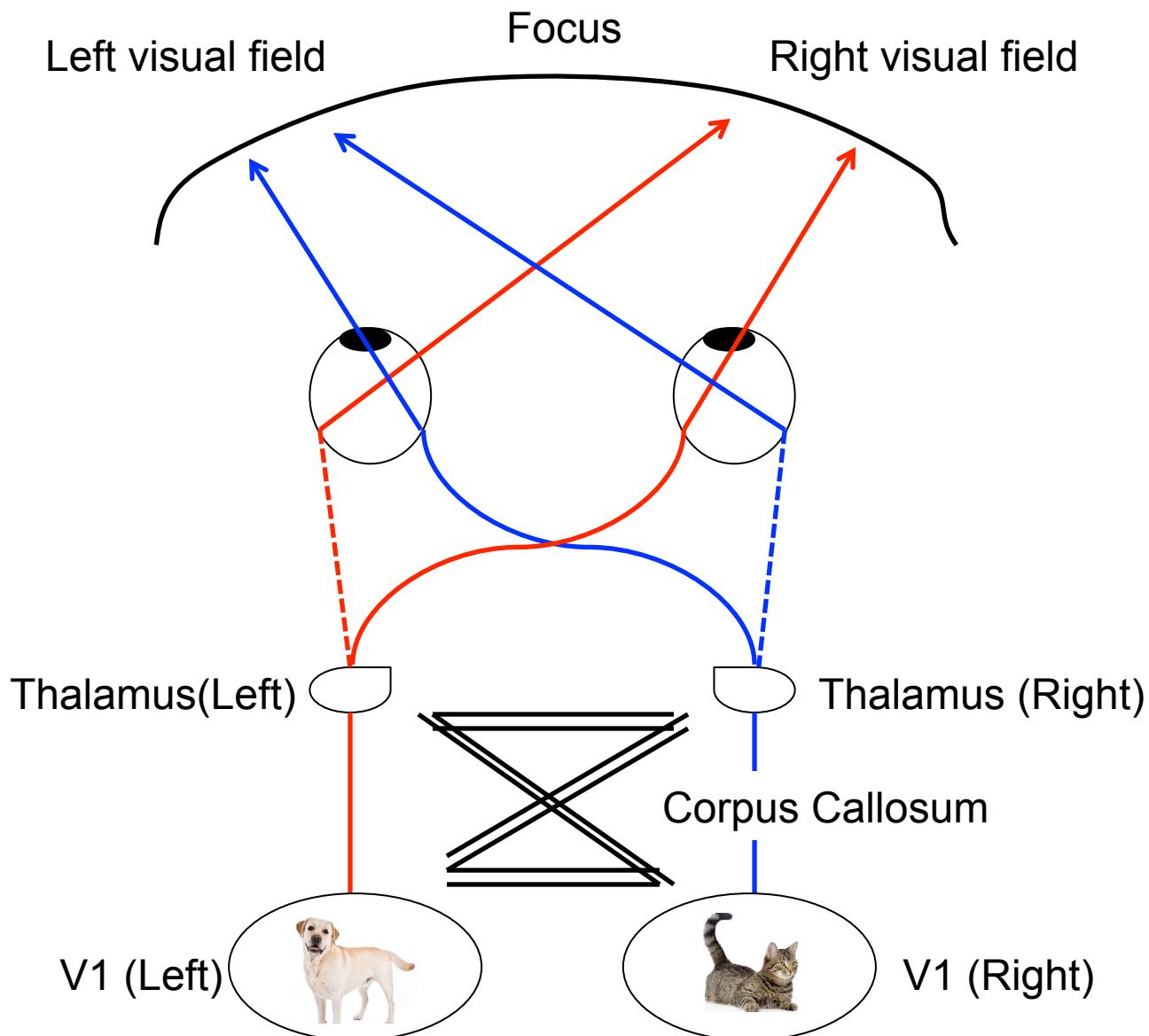
Left visual field

Focus

Right visual field

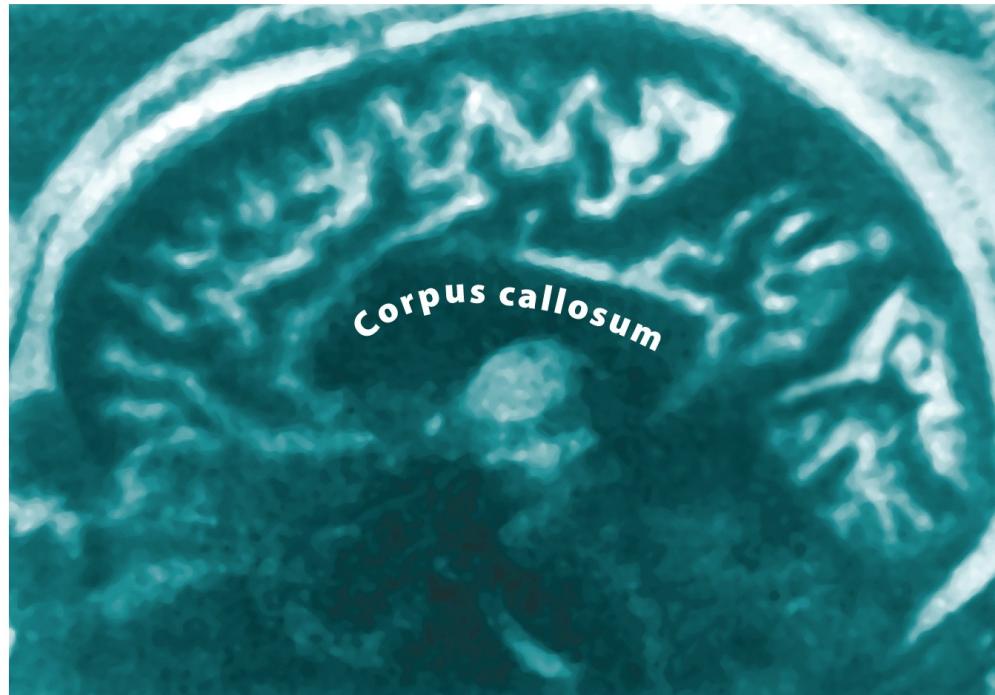




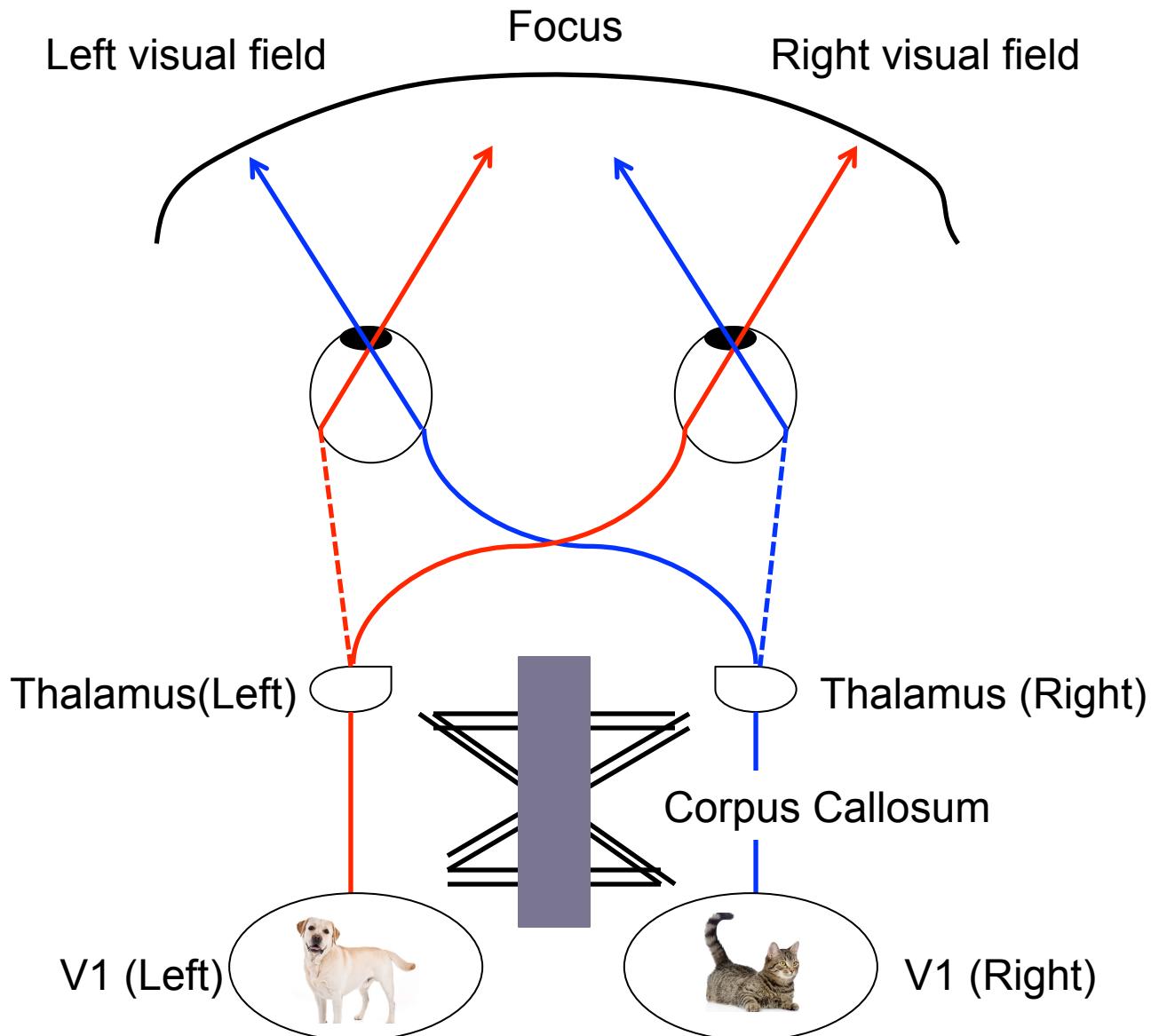


Split Brain Patients

- Surgery for epilepsy¹
 - Cut the CC to prevent seizures from jumping to other hemisphere



¹Roger Sperry & Mike Gazzaniga, 1960's

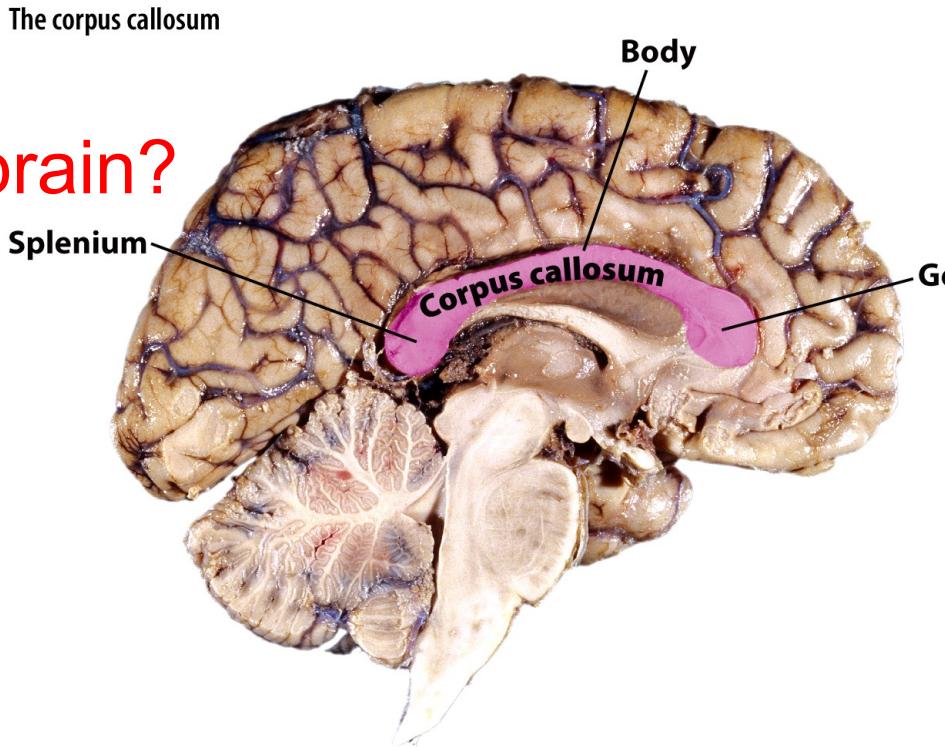


Corpus Callosum

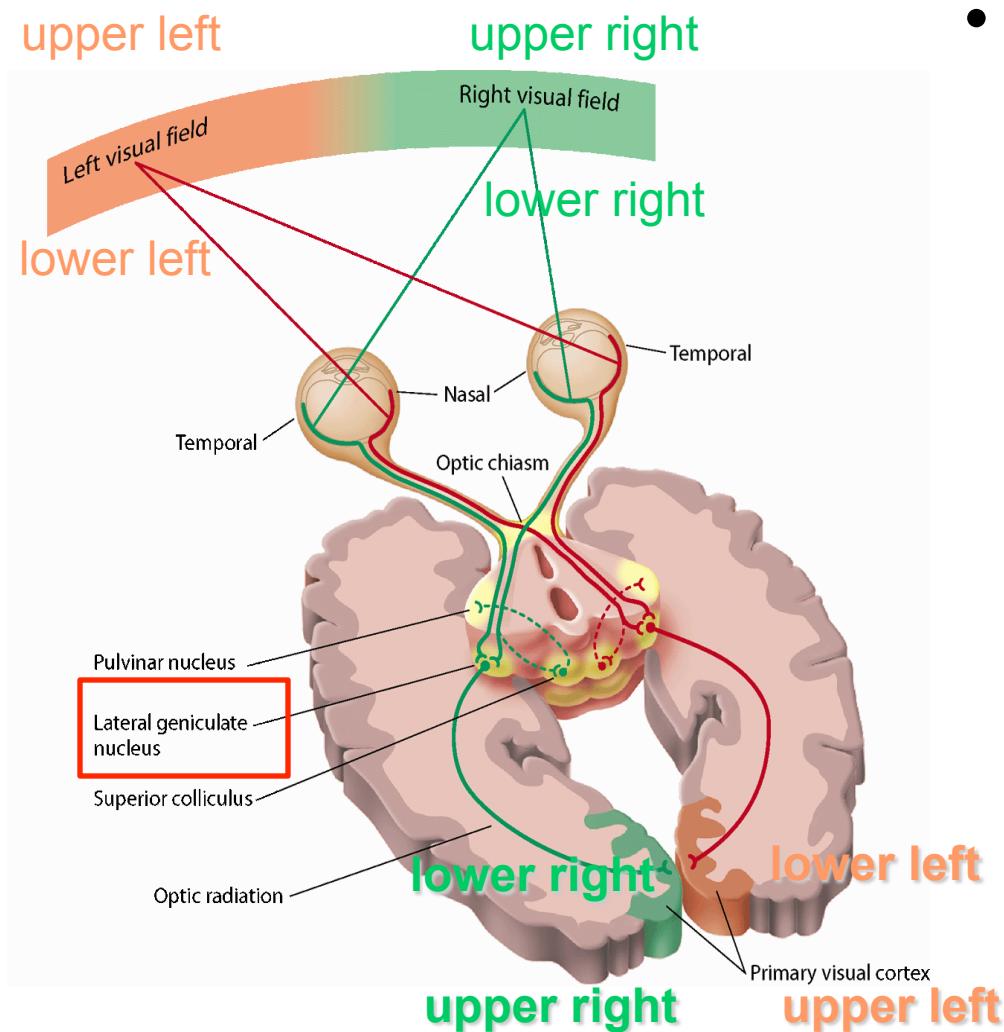
- The hemispheres of the brain are distinct yet connected
- Major pathway between hemispheres
- Major fiber tract for interhemispheric communication
- Transcallosal information transformation takes time.

Left or right brain?

Medial surface of
left hemisphere

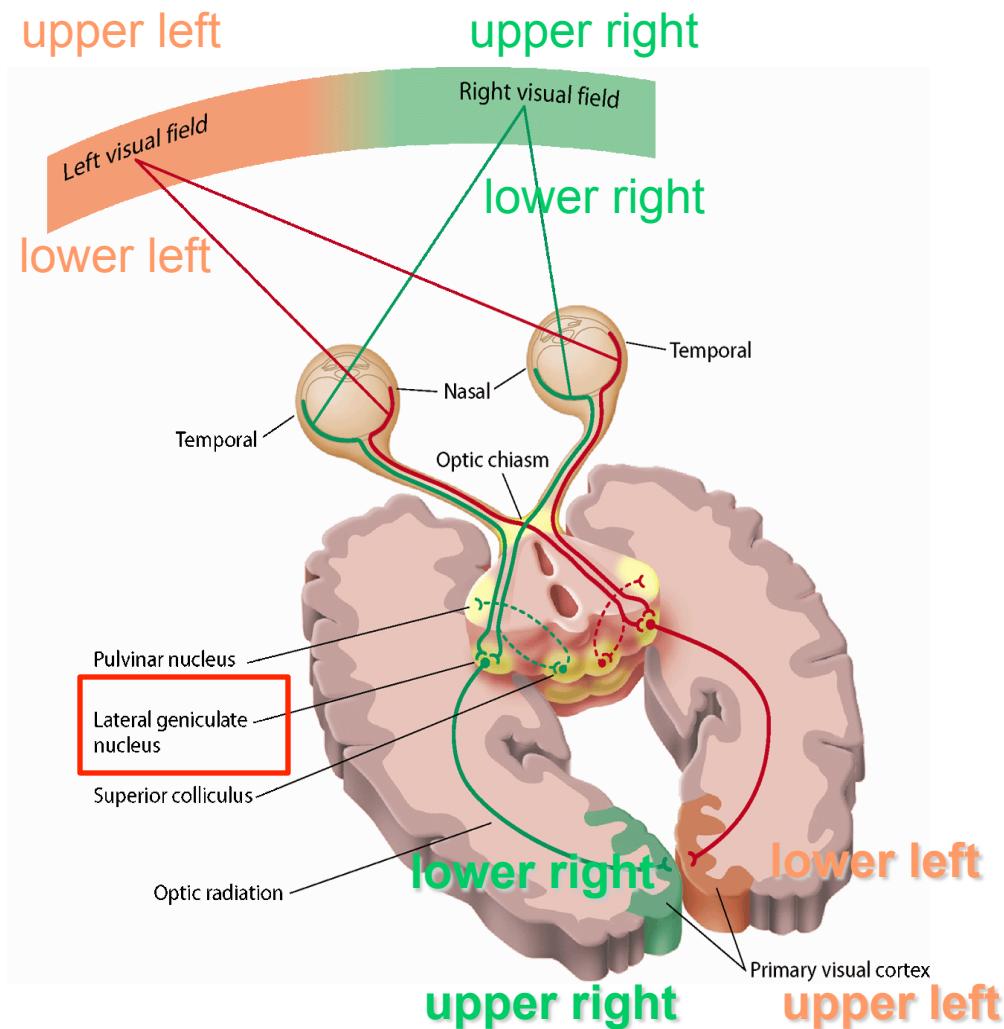


Visual cortex



- How do we use this to test hemisphere specialization?
 - Eye movements change visual field
 - Solution:
 - Eyetracking
 - Fast display <200ms
 - Faster than eyemovements

Visual cortex



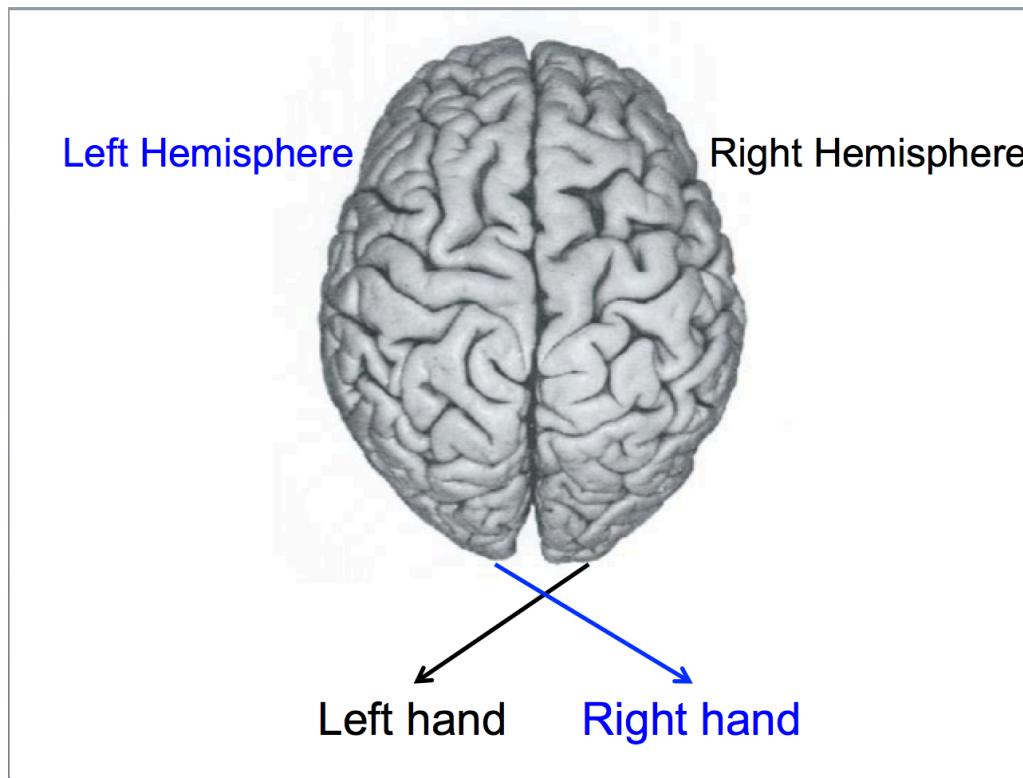
- If they move their eyes, the visual field will shift
- Need to control eye movements
 - Eye tracking
 - Fast display (faster than eye movements)

What happens when the CC is cut or disrupted?

- Each hemisphere still gets contralateral sensory input.
 - e.g. Information from left visual field goes to right hemisphere.
- Motor cortex in each hemisphere still controls contralateral side of body.
 - e.g. Commands from left M1 control right hand.
- BUT hemispheres can't communicate.
- Provides opportunity to present information to only one hemisphere and see if it gets processed.

Think, pair, share

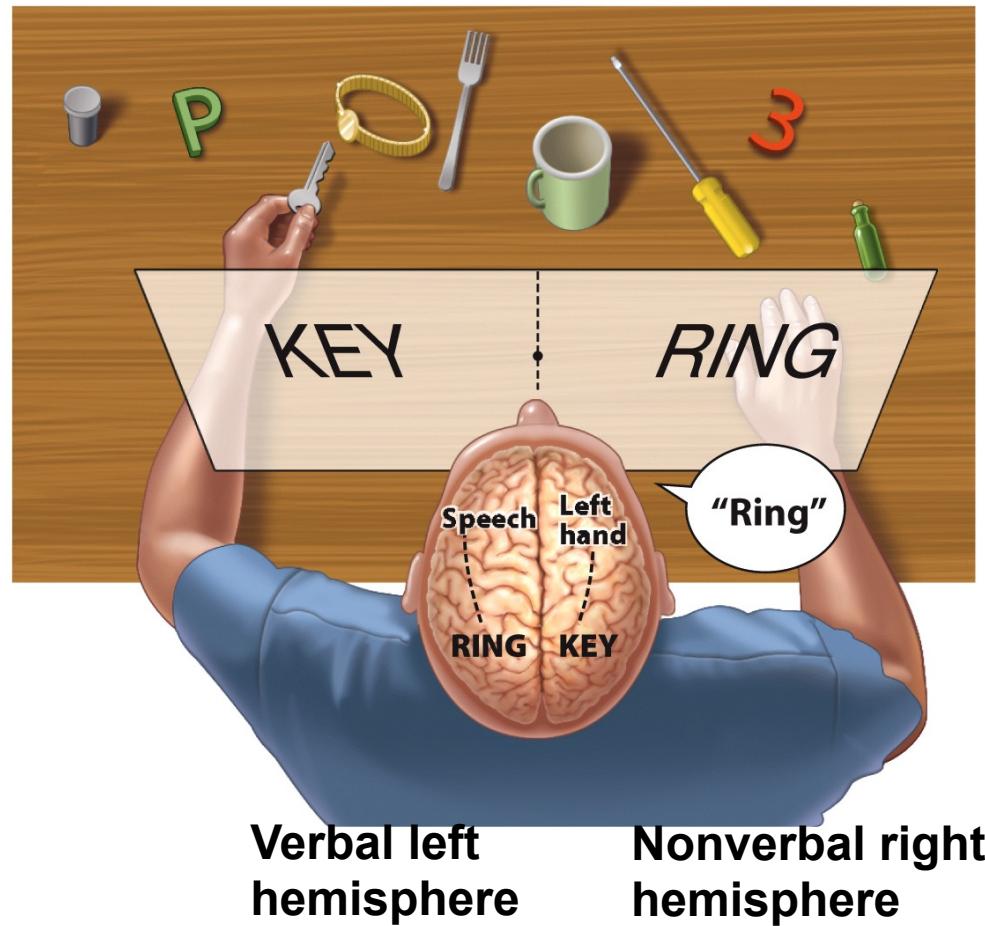
- Design a study to determine which hemisphere is involved in language production.



Language in LH

Special apparatus

- Screen blocks objects on table from view
- Picture input to just one side of brain
- Hands to identify objects by touch



Verbal left
hemisphere

Nonverbal right
hemisphere

Language in LH

Exp'ter: What did you see on the screen?

JW: Ring

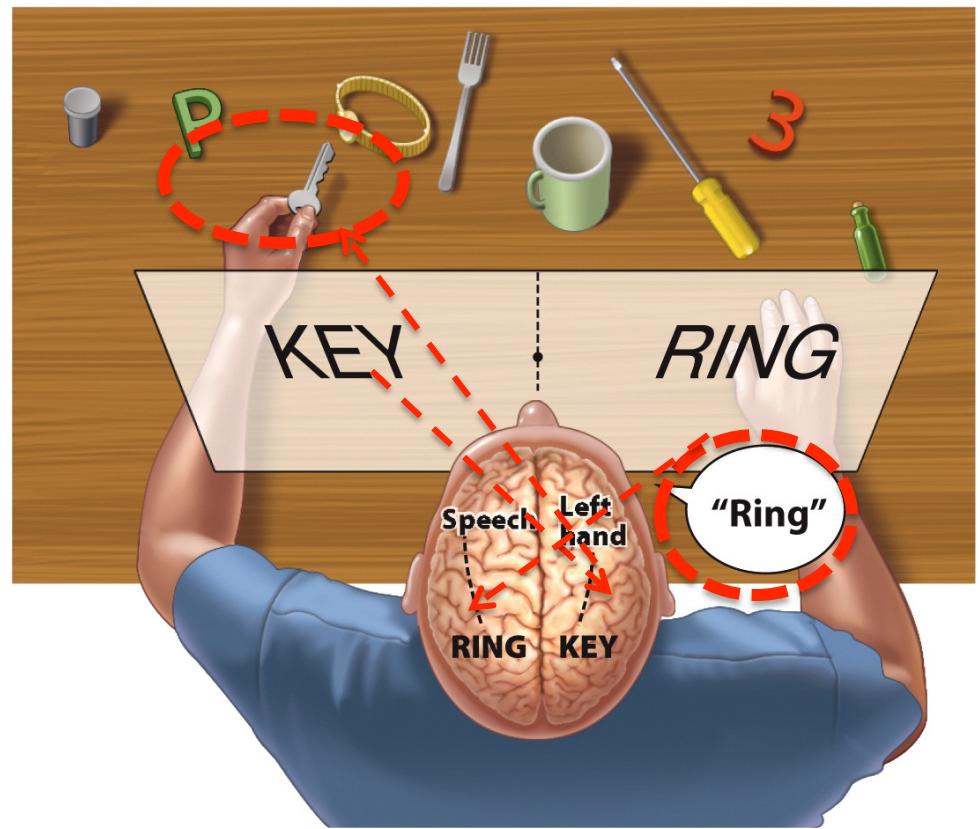
Exp'ter: Anything else?

JW: Nothing

Exp'ter: Pick up the object with your left hand

JW picks up the key

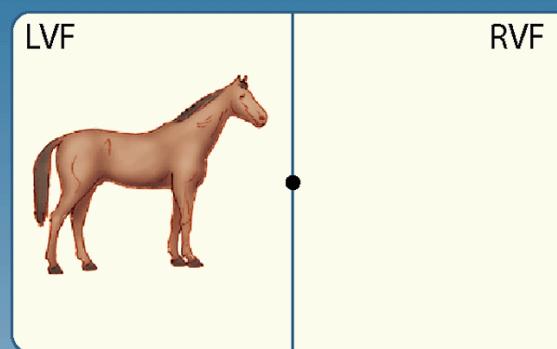
Only the LH can *produce* speech, but the RH has some basic language *comprehension*



Language in RH is limited

(a)

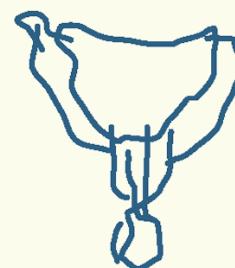
Visual stimulus



Examiner: "What was it?" "What goes on it?"

Verbal response: "I don't know." "I don't know."

Left-hand drawing:
(saddle)



RH has some comprehension, but no speech generation (as a rule).

Write the word with the ipsilateral hand and name it

RH: can write the LVF word, unable to name it

LH: can name the RVF word, unable to write it



Spatial Task in RH

- Coordination of motor plans disrupted in split-brain patient, resulting in competition.
- The spatial figure construction task
 - is perfect with his left hand (right hemisphere, RH, wins)
 - but fails with his right hand (left hemisphere, LH, wins, thus inhibiting the RH)

LH: left hemisphere
Right hand



RH: right hemisphere
left hand

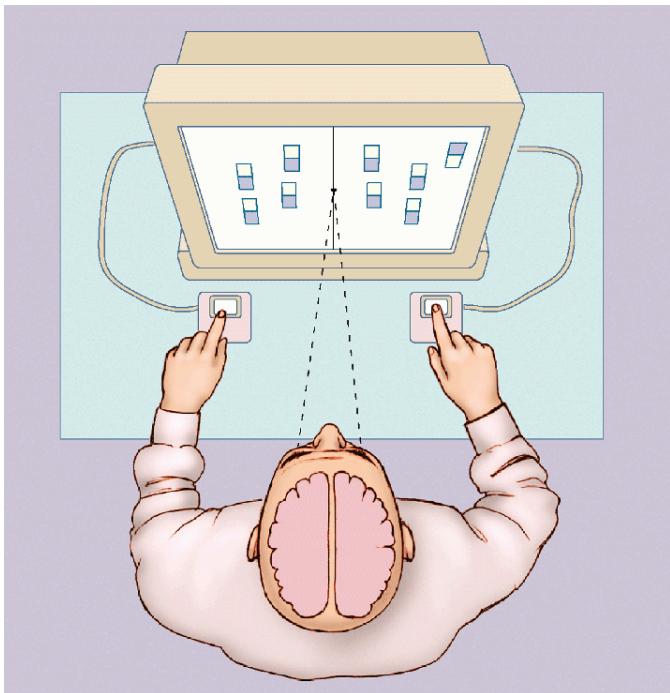
Just impairments?

- Is there any advantage to having two separate hemispheres?

Split-brain Patients: Double the Mind

Power?

- TASK: search for combination of two features
- Split-brain patients perform visual search tasks twice as fast as normal participants
- Suggests that each hemisphere has its own mind



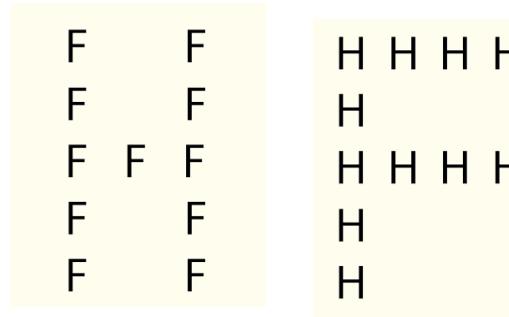
Split brain studies in humans

- Contributions:
 - Functional specifications
 - LH for language production, analytic
 - RH for visual-spatial processing and action
 - Each hemisphere can function independently (to some degree)
 - Even double cognitive capacity
 - No cross-hemisphere communication, with some residual cross-task via subcortical pathway
- Limitations:
 - Patients are not “normal” prior to surgery
 - Typically with extreme epilepsy
 - Findings are from a handful of patients
 - Brain imaging studies show that both hemispheres contribute to all functions but to a different degree

How can we study hemispheric specialization in normal cognition to test theories?

- Transcallosal information transformation takes time
- Visual half-field presentation without eye movements
 - Short exposure duration (under 200 ms) or fixation monitoring

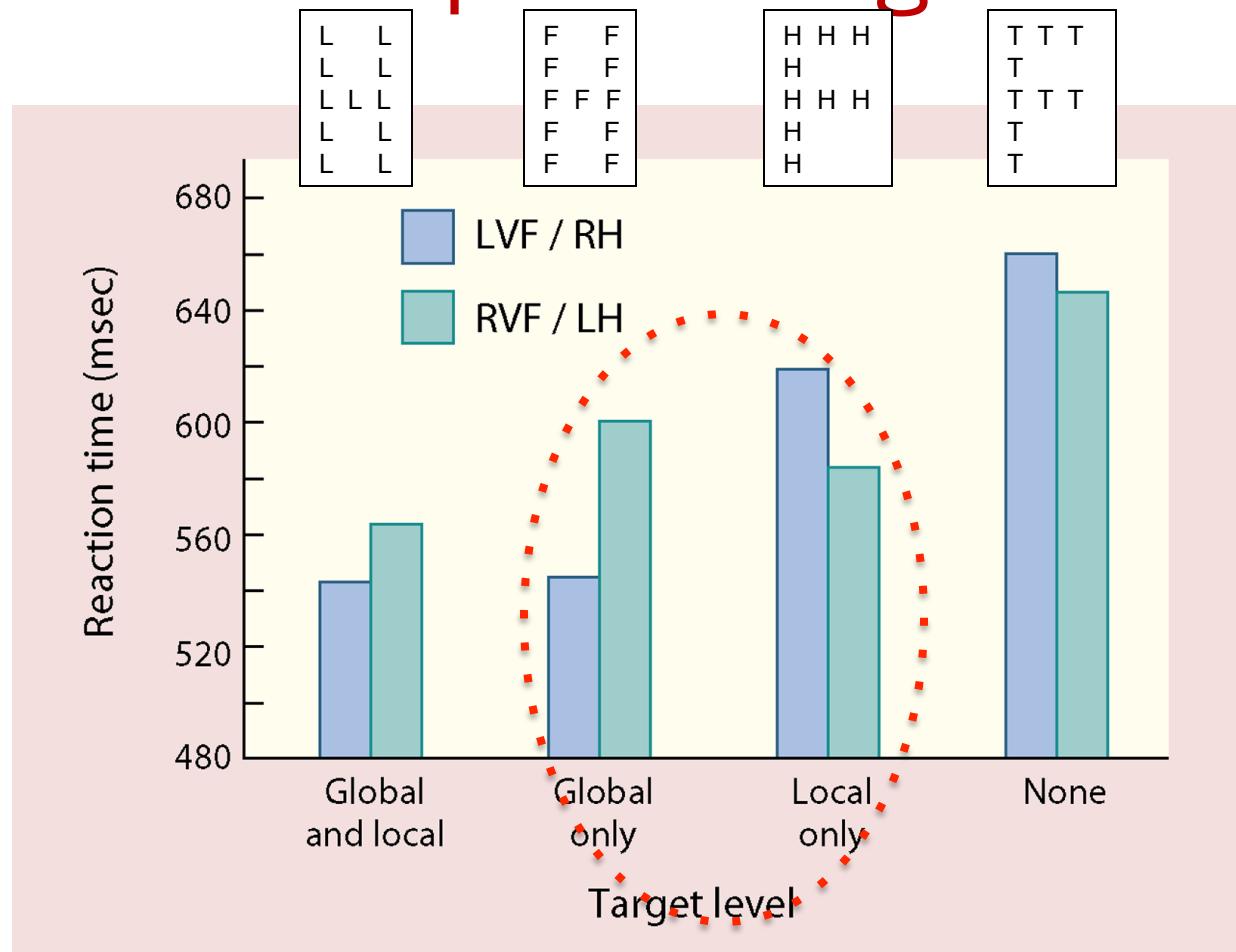
Ventral pathway - Local vs global processing



Navon Task:

- name global letter or
 - name local letter
- RTs faster for global

Ventral pathway - Local vs. global processing

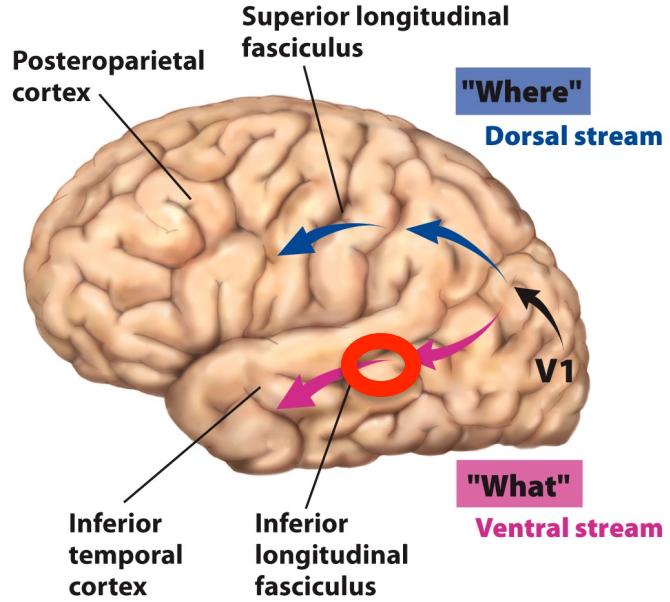


TASK: does the stimulus contain either an H or L?

RH better at global level, LH better at local level (but either can do task)

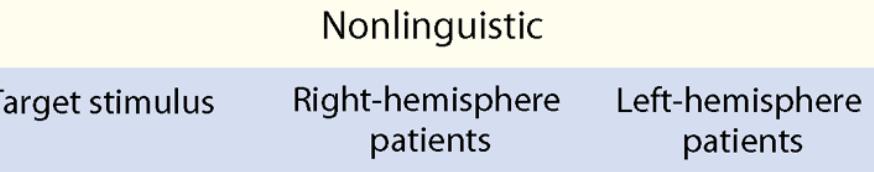
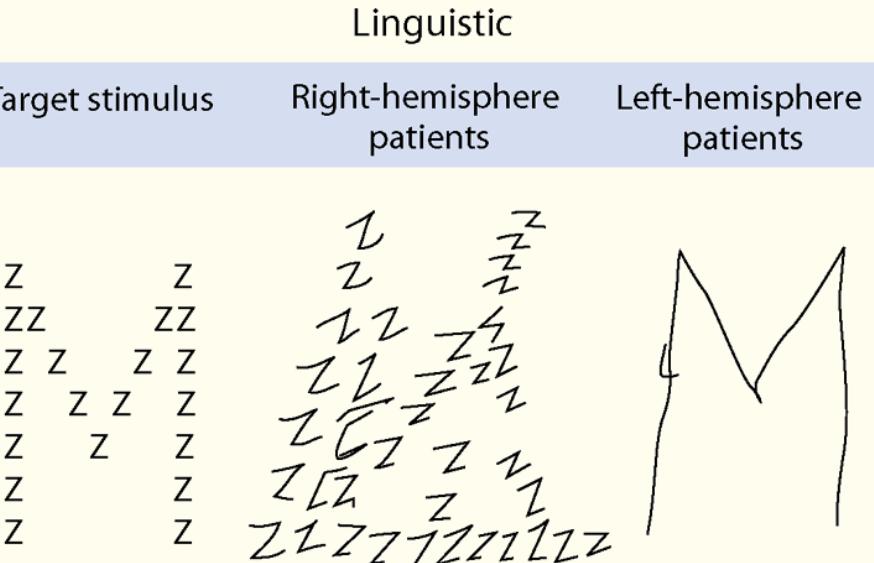
Local vs global processing

Unilateral lesions of temporo-parietal junction (what pathway)



LH patients: impaired at local processing

RH patients: impaired at global processing



Basis of global/local dissociation?

Spatial frequency hypothesis

- Spatial frequency
 - Level of detail present in a stimulus per degree of visual angle



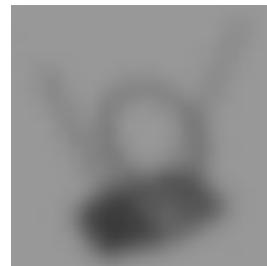
Ventral pathway: Spatial frequency hypothesis

- LH - better at processing high spatial frequency information
 - Allows perception of details/edges (local)
- RH - better at processing low spatial frequency information
 - Allows perception of whole/overall shape (global)



*Intact
LSF+HSF*

=



LSF (blob)

+



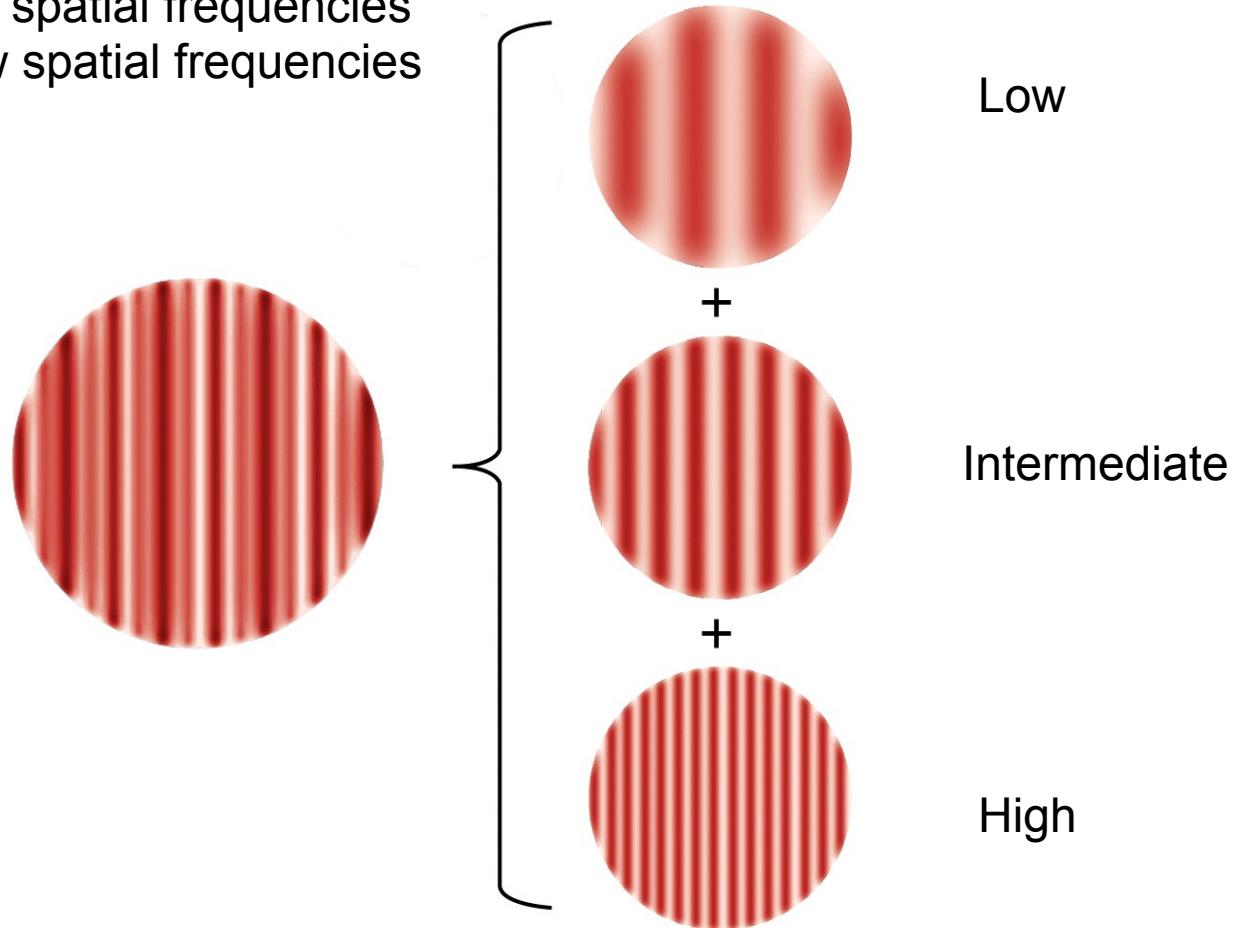
HSF (edge)

Basis of global/local dissociation?

Spatial frequency hypothesis

Perception involves processing different spatial frequencies

- local level based on high spatial frequencies
- global level based on low spatial frequencies

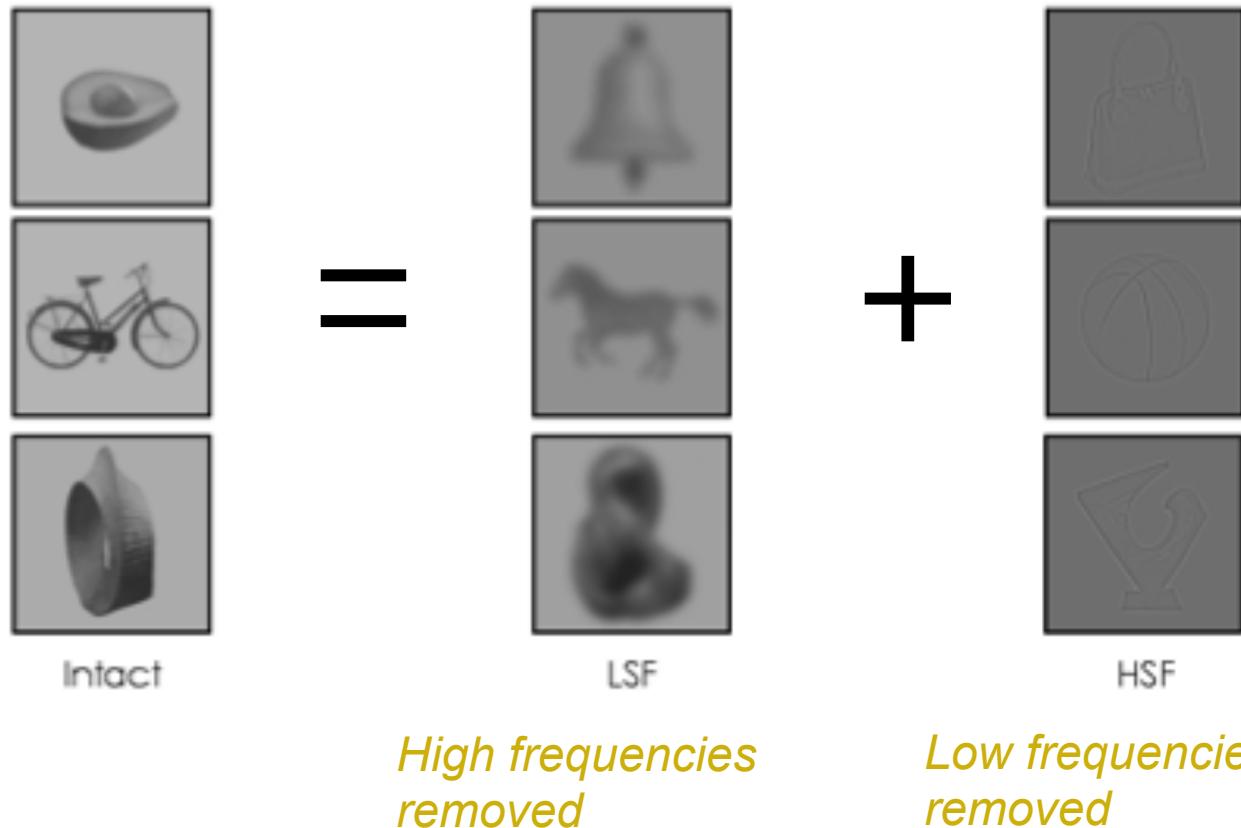


Basis of global/local dissociation?

Spatial frequency hypothesis

Perception involves processing different spatial frequencies

- local level based on high spatial frequencies (small objects & details)
- global level based on low spatial frequencies (large objects & overall shapes)



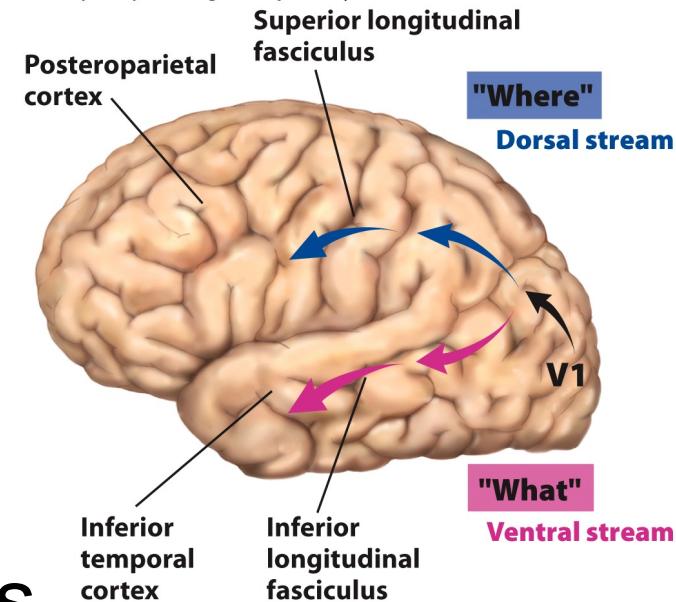
Hemispheric specialization

- we've talked about specialization in the “what” pathway (stimulus identification)

LH: local processing (high spatial frequency)

RH: global processing (low spatial frequency)

- “where” pathway?
 - stimulus spatial relations



Categorical vs Coordinate Reps

Specify the *relative position* btwn objects or btwn object and viewer

Specify the *exact positions and distances* btwn objects or btwn object and viewer



Categorical representation

Rocking chair left of couch
Dining chair right of couch

Coordinate representation

Rocking chair 2 feet from couch;
Rocking chair closer than dining chair to couch

Representing spatial relations:

- LH: categorical relations - abstract top/below, left/right
- RH: coordinate relations - specific metric, relative distance

Kosslyn (1989):

LH may be specialized for categorical relations because they can be represented in *verbal* terms

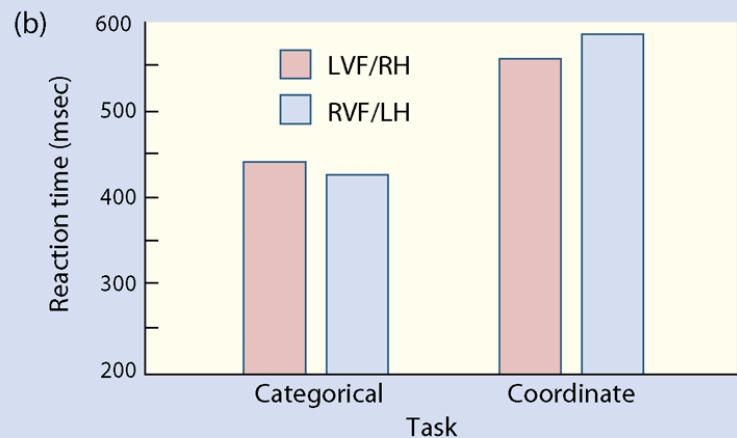
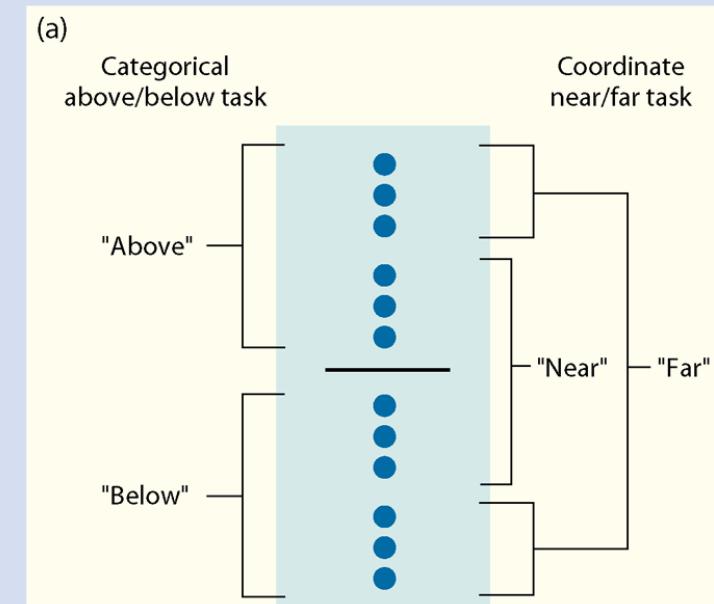
RH may be specialized for coordinate relations because it is superior for *visual-spatial* processing

Categorical (LH) vs Coordinate (RH) Reps

TASK 1 (categorical):
Is dot above or below line?

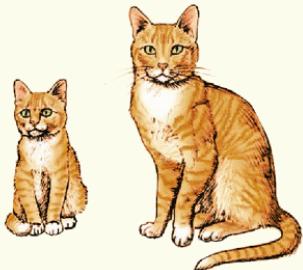
TASK 2 (coordinate):
Is dot near or far from line?

RTs faster
for categorical task in **RVF** (LH)
for coordinate task in **LVF** (RH)

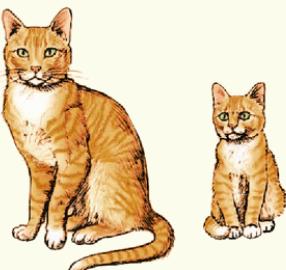


Categorical (LH) vs Coordinate (RH) Reps

Target



Categorical transformation probe



Coordinate transformation probe

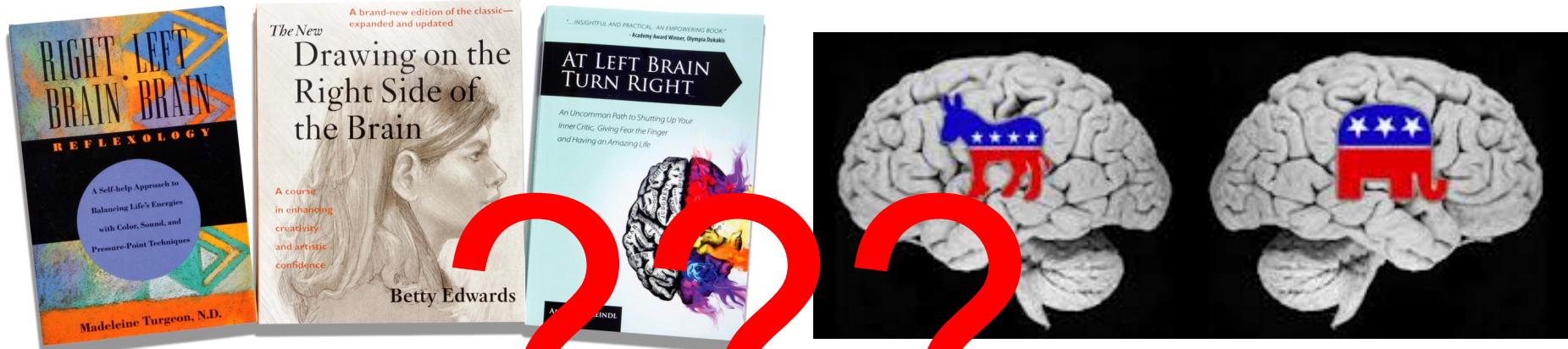


TASK: delayed match to sample

Patients with LH lesions worse on categorical mismatches

Patients with RH lesions worse on coordinate mismatches

Left- vs. Right- Brainer

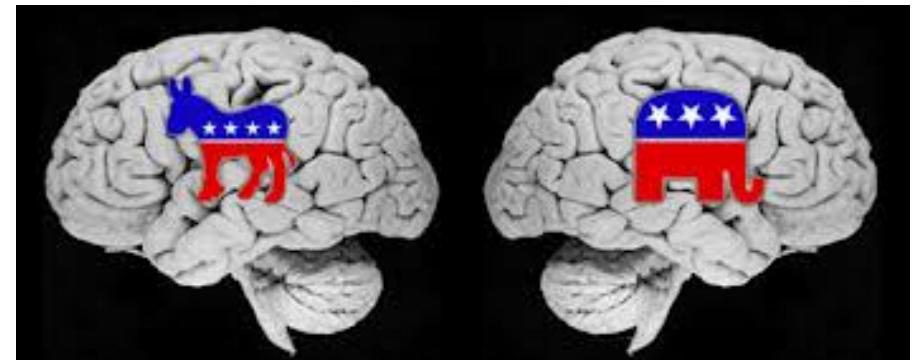
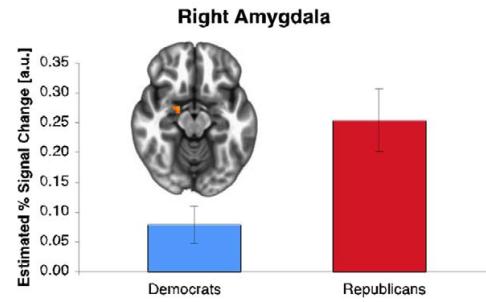
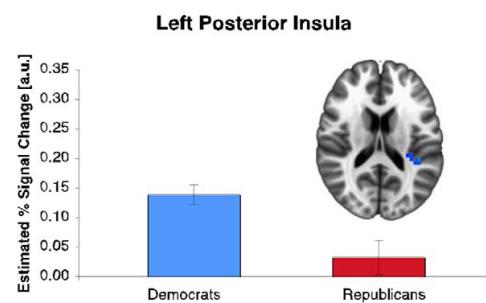


- Cognition
 - Left brain: language
 - Right brain: visuospatial processing.
- Personality
 - left-brain: verbal, analytic, dominant, copywriter
 - right-brain: artistic, the instantaneous, “flash-of-insight”, art director

Political Brain

Schreiber et al. (2013)

- Democrats: activity in the left posterior insula
- Republicans: increased activities in the right amygdala
- Can predict one's political affiliation with 82.9% of success rate!
- Neuromarketing & politics
- E.g., Republican candidates appearing on the left side in campaign video



Not about Left vs. Right

- Not really about neural/genetic foundations for the differences in ideology.
- Rather it is about the differences in cognitive processing
- Conservatives show greater sensitivity to threatening stimuli, which is processed in amygdala (week 7).
- Liberals show greater activity in insula, the neural center for “theory of mind”, the ability to understand what others might be thinking (week 9).

Maybe Not

- Sperry warned that “experimentally observed polarity in right-left cognitive style is an idea in general with which it is **very easy to run wild**... it is important to remember that the two hemispheres in the normal intact brain tend regularly to **function closely together as a unit**” (1984, *Neuropsychologia*).
- Can be left-handed or right-handed, but no clear dominance in hemisphere.

Even a simple task involves many cognitive functions that may not be lateralized

Hemispheric Specialization

Essentials

- Language
 - RH – language comprehension only
 - LH – both language production and comprehension
- Visuo-spatial
 - RH – intact
 - LH – impaired
- Ventral pathway
 - RH – global and low spatial frequency
 - LH – local and high spatial frequency
- Dorsal pathway
 - RH – coordinate (distance)
 - LH – categorical (relative position)

Hemispheric Specialization

Essentials

- Corpus callosum
- Split-brain studies
 - LH: language
 - RH: visual-spatial and motor
- Functional asymmetry in ventral pathway
 - unifying principles
 - local vs. global (holistic) processing
 - low vs. high spatial frequencies
- Functional asymmetry in dorsal pathway